

Dual Microstructure Heat Treatment of a Nickel-Base Disk Alloy Assessed

Gas turbine engines for future subsonic aircraft will require nickel-base disk alloys that can be used at temperatures in excess of 1300 °F. Smaller turbine engines, with higher rotational speeds, also require disk alloys with high strength. To address these challenges, NASA funded a series of disk programs in the 1990's. Under these initiatives, Honeywell and Allison focused their attention on Alloy 10, a high-strength, nickel-base disk alloy developed by Honeywell for application in the small turbine engines used in regional jet aircraft. Since tensile, creep, and fatigue properties are strongly influenced by alloy grain size, the effect of heat treatment on grain size and the attendant properties were studied in detail. It was observed that a fine grain microstructure offered the best tensile and fatigue properties, whereas a coarse grain microstructure offered the best creep resistance at high temperatures. Therefore, a disk with a dual microstructure, consisting of a fine-grained bore and a coarse-grained rim, should have a high potential for optimal performance.

Under NASA's Ultra-Safe Propulsion Project and Ultra-Efficient Engine Technology (UEET) Program, a disk program was initiated at the NASA Glenn Research Center to assess the feasibility of using Alloy 10 to produce a dual-microstructure disk. The objectives of this program were twofold. First, existing dual-microstructure heat treatment (DMHT) technology would be applied and refined as necessary for Alloy 10 to yield the desired grain structure in full-scale forgings appropriate for use in regional gas turbine engines. Second, key mechanical properties from the bore and rim of a DMHT Alloy 10 disk would be measured and compared with conventional heat treatments to assess the benefits of DMHT technology.



Alloy 10 DMHT disk.

At Wyman Gordon and Honeywell, an active-cooling DMHT process was used to convert four full-scale Alloy 10 disks to a dual-grain microstructure. The resulting microstructures are illustrated in the photomicrographs. The fine grain size in the bore can be contrasted

with the coarse grain size in the rim. Testing (at NASA Glenn) of coupons machined from these disks showed that the DMHT approach did indeed produce a high-strength, fatigue-resistant bore and a creep-resistant rim. This combination of properties was previously unobtainable using conventional heat treatments, which produced disks with a uniform grain size.

Future plans are in place to spin test a DMHT disk under the Ultra Safe Propulsion Project to assess the viability of this technology at the component level. This testing will include measurements of disk growth at a high temperature as well as the determination of burst speed at an intermediate temperature.

Glenn contact: Dr. John Gayda, 216-433-3273, John.Gayda@grc.nasa.gov

Author: Dr. John Gayda

Headquarters program office: OAT

Programs/Projects: Ultra Safe, UEET